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13. ABSTRACT

Acid-Base values in guinea pigs were measured during artificial respiration under normal pressure and at a pressure of 19.2 atmospheres. It was found that artificial respiration maintained normal acid-base balance under both conditions. In addition, it was found that the acid-base values in normal animals did not agree well with those previously reported in the literature.

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Acid-Base Balance in Artificially Respired Guinea-Pigs under Normal Conditions and During Exposure to Hyperbaric Helium

Certain drug evaluation procedures being used in this laboratory necessitate the use of artificial respiration of guinea-pigs during exposure of the animals to a hyperbaric helium atmosphere. In order to ascertain that the artificial ventilation maintained normal acid-base balance, arterial blood pH was measured in guinea-pigs during artificial respiration either at normal or elevated pressure. In animals respired at normal pressure, arterial blood pO_2 and pCO_2 were also measured. The pH and gas values were compared with values found in unanesthetized and in anesthetized, non respired animals. The values for pH and pCO_2 determined for normal animals were not in good agreement with previously reported values[1].

Four groups of male guinea-pigs of the NMRI (Hi strain, weighing 302–500 g, were used. In group I (normal, unanesthetized), a length of PE-50 tubing was inserted in the carotid artery while the animals were under light ether anesthesia. 4 h following recovery from anesthesia, carotid artery blood samples were drawn for analysis. In group II, animals were anesthetized with Dial-urethane soution (0.6 ml/kg, i.p.) and the carotid artery was cannulated as in the first group. Duration of anesthesia was greater than the remainder of the experiment, and arterial blood samples were drawn 4 h after completion of surgery. Groups III-A and III-B (artificially respired animals exposed to normal or high pressure, respectively) were treated in the same manner as animals in group II, but, in addition, the trachea was cannulated and the animals were connected to a piston-type small animal respirator with inflation volume set to provide an inflation pressure of 65 mm H_2O.

The respirator was set at a rate that just prevented animals from breathing spontaneously, and this rate was determined by trial and error for each animal. The suppression of spontaneous respiration was considered to result primarily from operation of an inhibitory respiratory reflex (Hering-Breuer inflation reflex). The possibility that hyperventilation contributed to the suppression cannot be totally ruled out, but this contribution must have been quite small in view of the normal arterial blood pH values subsequently measured in these animals.

Blood samples from animals in group III-A were obtained after 1 and 4 h of artificial respiration. Animals in group III-B were pressurized in a hyperbaric chamber[2] to a total pressure of 28.2 *ATA* (final composition of the hyperbaric atmosphere was $pHe = 19.0$ atm.; $pO_2 = 0.2$ atm.). Blood samples from animals of group III-B were obtained 1 and 4 h after pressurization. Gas and pH values for group III-A, and pH values for group III-B, measured in

[1] P. L. ALTMAN and D. S. DITTMER, *Biolog. Data Book* (Federation of American Societies for Experimental Biology, Washington, D.C. 1964), p. 266.

[2] A. SMALL, Toxic. appl. Pharmac. *17*, 250 (1970).

Arterial blood pH and gas tensions in guinea-pigs[a]

	Unanesthetized Animals (Group I)[b]				
	Present Data	Data of HAWKINS[c]	Group II[b]	Group III-A[b]	Group III-B
pH	7.50 ± 0.02	7.35 ± 0.03	7.40 ± 0.03[e]	7.50 ± 0.02	7.49 ± 0.03
pCO_2	31 ± 1	33 ± 3[d]	47 ± 3[e]	32 ± 2	–
pO_2	81 ± 2	–	73 ± 5	85 ± 3	–
n[f]	15	12	11	10	10

[a] Values represent mean ± S.E. [b] Designation of groups. Group I, unanesthetized, spontaneously breathing; Group II, anesthetized, spontaneously breathing; Group III-A, anesthetized and artificially respired at normal pressure; Group III-B, anesthetized and artificially respired at 282 γ. [c] Blood obtained by cardiac puncture [1]. [d] Reported as volume percent CO_2 and converted to pCO_2 by standard formula[4]. [e] Significantly different than values for animals in Group I ($p < 0.01$, Student t-test). [f] n = number of animals.

the 1-hour sample, served as a guide for adjusting the rate of artificial respiration for the remainder of the experiment.

Blood pH, pCO_2, and pO_2 were measured with an Instrumentation Laboratories Model 113 analyzer. In animals of group III-B, only pH could be measured accurately because effervescence in decompressed blood interfered with measurement of pCO_2 and pO_2. A 2-ml sample of blood was sufficient for the analyses. Results for the 4 groups of animals are shown in the Table. The data demonstrate that anesthesia significantly depressed respiration in spontaneously breathing guinea-pigs (group II) as compared with normal animals (group I). However, the Table also shows that the artificial respiration used in these studies (groups III-A or III-B) successfully reversed the respiratory depression and maintained the animals in normal acid-base balance. Apparently, artificial ventilation was not appreciably affected by the use of a gas mixture that was approximately 2.9 times as dense as air at a pressure of 1 atm.

It is interesting to compare the present data with previously published values for pH and pCO_2 in guinea-pigs, also given in the Table. Currently cited values for normal guinea-pigs[1] are based on the work of HAWKINS[2], who analyzed blood obtained by cardiac puncture, using the Van Slyke method to determine total CO_2, and a comparator block method to estimate pH. Results obtained with cardiac puncture blood should be interpreted with caution because of the likelihood of aspirating a mixture of arterial and venous blood. The Table shows that HAWKINS reported nearly the same pCO_2, but a much lower pH than was found in the present study.

In conclusion, the present data demonstrate that artificial respiration of guinea-pigs, as performed in this laboratory, provided adequate ventilation of the animals, both at normal pressure and in a hyperbaric helium atmosphere. In addition, the pH and pCO_2 reported here for unanesthetized animals may be closer to true values for normal guinea-pigs than are the currently cited values[3,5].

Zusammenfassung. Säure-Basen-Werte von Meerschweinchen (*Cavia porcellus* L.) wurden unter künstlicher Atmung bei normalem Druck und bei Druck von 19.2 Atm. gemessen und festgestellt, dass künstliche Atmung unter erhöhtem Druck normale Säure-Basen-Gleichgewichte gewährleistet, während die Säure-Basen-Werte normaler Tiere mit denjenigen der Literatur nicht übereinstimmten.

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[1] J. A. HAWKINS, J. biol. Chem. 61:147 (1924).

[2] J. H. COMROE, JR., R. E. FORSTER II, A. B. DUBOIS, W. A. BRISCOE and E. CARLSEN, *The Lung* (Year Book Medical Publishers, Inc., Chicago, Ill. 1962), p. 155.

[3] From Bureau of Medicine and Surgery, Navy Department, Research Task No. M4306.02.5031. The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.

[4] Experiments reported herein were conducted according to the principles enumerated in *Guide for Laboratory Animal Facilities and Care*, prepared by the committee on the Guide for Laboratory Animal Resources, National Academy of Sciences, National Research Council, Washington, D.C.